Improving CMOS Sensors via Quasi-Transparent Secondary Sensors and Repurposed LiDAR Prisms: Prismatically-Enabled Synthetic Aperture Optical System (PESAOS)

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Introduction

Although SPIN/OPT sensor arrays enable imaging with single-photon resolution, their ultimate per-unit cost remains unclear. Perhaps the most complex aspect of such sensors isn't the innovative polarity control and binning/routing system, but the system for amplifying the weakest of electrical impulses in a manner that enables faithful measurement of signal inputs.

Abstract

Traditional CMOS systems utilize sensors that are square and flat and somewhat wider than the phase height of near-IR light. CMOS senses waves of light, each of which, in reasonable lighting conditions consist of a great many photons.

In 2009, this author proposed a concept which was rapidly adopted that involved the artificial improvement of sensor resolution by actuating sensors in extremely small increments and generating a meta-image that can accurately reflect the visual field in the spaces between pixels. This means fusing data from a series of short exposures, doing for cameras what the synthetic aperture did for RADAR. Hasselblad was the first to patent the technology, but before long, it started showing up in military and, eventually, other commercial platforms.

Another technology that emerged from this author from just prior to that time was the non-repeating thickness prism in support of what came to be known as flash LiDAR. It now seems there may be a way to fuse the unique prism technology with a traditional CMOS sensor to build superior synthetic aperture visual images without the actuation mechanism first described in 2009. Where that system can take a 50MP sensor and, under ideal conditions, generate a "200MP image," this requires phenomenally stable (vibration free) shooting conditions.

Photosensors as we understand them are agnostic to where within the area of a specific sensor node a wave is striking. A wave could have any number of orientations of polarity or could even straddle two sensors. Every wave of light has an estimable center of phase variance. This is to say that each phasing of the light has two crests with a point halfway between that could be termed the true center of the wave as it is detected by the flat sensor.

The addition of a prismatic foil over the top of a traditional CMOS sensor array that can in and of itself act as a sensor that is mostly transparent (i.e. it only absorbs a fraction of the photons in the wave to make a measurement) would allow for a much richer synthetic aperture to be created without

needing to physically actuate the sensor.

Unlike the polarity control system described on 22Aug2021 that alters polarity deliberately and bins according to polarity to affix position non-synthetically, this system would be a form of synthetic imaging that may have as a benefit lower manufacturing costs (versus SPIN/OPT) while still offering undeniable improvement over existing opto-electronic systems. Furthermore, this system would not require exceedingly long exposures and thus does not have the restrictive tolerances on vibration of the physical sensor actuation approach.

The specialized coating over the traditional CMOS layer would, itself, consist of two layers. The outermost is a version of the traditional CMOS that is optically transparent and non corruptive to frequency. This layer takes a measurement of the frequency of a given wave of light while leaving most of its energy intact.

Beneath this layer, a non-repeating thickness prism that deliberately alters frequency differently depending upon thickness is situated between a transparent sensing layer and the final sensing layer. As you may recall, these prisms are constructed by the generation of a magnetically-active crystalline structure in which nodes start off close together and are placed at increasing intervals in an additive process. The surface of this prism is then ablated so that its thickness is never the same at any two points. This can be done with a type of laser etching in which the prism is oscillated in a whirling pattern with a constantly widening axis and a fixed laser that steadily increases its power. Thus, no two points have the same thickness and all points alter light differently. Doing this in a swirl pattern is actually ideal not only for LiDAR, but for our enhanced synthetic optics application as well.

This is because the pattern of phasing light striking sensors, if it could be visualized, would like a series of lash-marks with different angular orientations. This is due to the naturally variable polarity of light which, in this case, does not present a problem.

Even though our sensors are nearing the limits of miniaturization, this approach means that the granularity of an image is no longer tethered exclusively to the miniaturization of a sensor array.

By measuring the time and location of the arrival of light waves, measurements of the same light wave may be made twice and the data logically paired for later analysis. The combination of unique frequency-distortion nodes (the size of these nodes are measured in angstroms) enables the rear sensor to detect a whole range of frequencies none of which are the original frequency.

While the forward transparent sensor informs the system of the true color of a wave of light, the way in which the light is distorted (range of frequencies detected by the rear sensor relative to the forward-detected frequency) informs the system of the angstrom-precise one-dimensional strike area of the wave as a whole. With this data, the exact center of that line becomes the location of the synthetic pixel.

Conclusion

In short, one layer measures color, and with the help of a sophisticated prism, the second may assign that color to a synthetic pixel far more granular than traditional sensors alone would allow. While it is difficult to estimate the upper limits of the potential of this approach, with a (true) 50MP sensor as a starting point, it would not be unreasonable to expect to be able to derive faithful 50GP images from a 50MP sensor using the prescribed approach. This constitutes an order of magnitude improvement to what may be achieved with a modified form of CMOS.